Observations on Age and Growth of *Tachysurus sona* (Ham.)[1]

BY

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(*With eight text-figures*)

INTRODUCTION

The sub-order Siluroidea is represented mainly by the family Tachysuridae (Ariidae) along the Bombay coast, where it is of considerable economic importance. Its fishery along the coast has improved considerably with the recent introduction of mechanised fishing boats and motor trawlers which have more or less replaced the use of hook and line (restricted to the monsoon season only) as the principal mode of capture of catfishes. Catfishes ranked second in the total marine fish catches of Maharashtra for the years 1962-63 and 1963-64 (Annual Report 1963-64, Department of Fisheries, Maharashtra). Of the six species of commercial importance along the Bombay coast, the husky catfish, *Tachysurus sona* locally known as ' Shigala ' ranks first, constituting about 60% of the catfish catches. Practically no information is available on the biology of this fish. The present study, however, deals only with the age and growth of the fish.

Growth studies of fishes have become an important aspect of fishery biology investigations in view of their use in population models for estimating the yield of a fishery. The yield estimate from population models such as those given by Beverton & Holt (1957) is obtained in terms of weight of the fish caught, for which a correct knowledge of growth parameters and length-weight relationship are necessary besides other vital statistics like catch and effort. The growth parameters obtained in the present study are based on vertebral reading supplemented by the evidence obtained from the length-frequency polygons.

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Material and Methods

The material which formed the basis of the present study was collected from the catches of bag-nets (*Dol jal*), long-lines and trawls at Sassoon Dock. Some samples were also collected from different landing places in Bombay such as Chaupatty and Versova, during the monsoon months. Samples were collected at fortnightly intervals and care was taken to collect an unbiased sample of the catch.

Total length of each fish was measured to the nearest millimetre from the tip of the snout to the tip of the upper lobe of the caudal fin. Weight of the fish was taken to the nearest gramme by using a Salter pan balance for smaller fishes but for bigger fishes, weighing one kilogram or more, a spring balance was used.

For age reading, fifth vertebra which lies behind the 'complex vertebra' described by Karandikar & Masurekar (1954) was selected as it is flat and easy to separate. The use of vertebrae was necessitated by the absence of scales in *T. sona.* Pantulu (1961, 1962 & 1963) developed the use of pectoral spines in medium sized catfishes, while Saigal (1963) pointed out that vertebrae can also be used in determining the age of the freshwater catfish, *Mystus aor* (Ham.). Since *T. sona* grows to a large size, the use of pectoral spine could not be made for age reading because of difficulties in obtaining suitable sections. Many earlier workers have made use of vertebrae for the study of age and growth of fishes, (Heincke 1908, Appleget & Smith 1951, Partlo 1955, Mather & Schuck 1960).

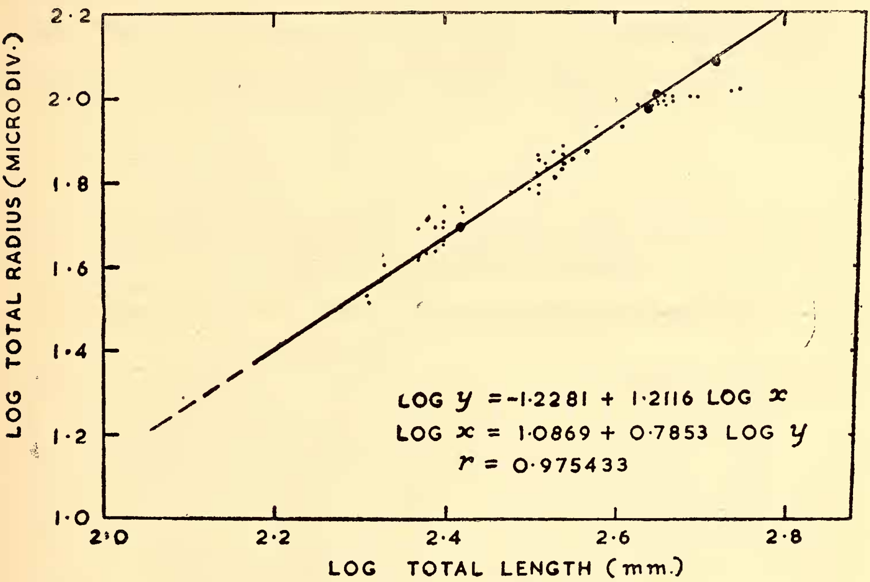
For obtaining the fifth vertebra a portion of the body containing the first few vertebrae was cut off and boiled in water for about five minutes so as to remove the adhering tissue. Then the fifth vertebra was separated from the rest with the help of a scalpel. While separating the vertebra, all possible care was taken not to damage the margin of the vertebra. In some cases where the margins were found damaged, the specimens were discarded. The vertebrae were cleaned in ether so as to remove adhering fat and then kept in glycerine for about a week until the growth rings became clearly visible. To discriminate the true and false rings, a few vertebrae with very clear rings were stained by Galtsoff's (1952) method and kept as model specimens for comparison.

The vertebrae showed alternating narrow (dark) and wide (opaque) concentric zones, around a centre. True and false rings could be easily distinguished by their circular continuity or discontinuity respectively.

The distance of each ring was measured from the centre along a radial plane to the longest axis of the vertebra. Measurement of each zone was done by a micrometer eye piece. In all fifty-one vertebrae were examined and growth checks from each were measured.

Age and Growth

The length of *T. sona* at the time of formation of successive annuli was back calculated for each fish by making use of the relationship between the radius of the vertebrae and the length of the fish.



Text-Fig. 1. Relation between vertebral radius and total length of the fish. Points denote observed values.

This relationship is shown in Figure 1 and was found to be linear in the logarithmic form which can be expressed as

$$\log y = a + b \log X$$

where y=radius of the vertebrae and X=length of the fish and 'a' and 'b' are the two constants. The straight line relationship between the vertebral radius and length of *T. sona* is found to be

$$\log y = -1{\cdot}2281 + 1{\cdot}2116 \log X \;\ldots.\; (1)$$

which can be conversely expressed as

$$\log X = 1{\cdot}0869 + 0{\cdot}7853 \log y \;\ldots.\; (2)$$

The correlation coefficient 'r' of the two variables is found to be 0·975433, which is highly significant.

In deriving a formula for back-calculation it was considered more appropriate to take into consideration the regression of the total length on radius of the vertebrae (2), (Smith 1955, Pantulu & Singh 1962, and Pantulu op. cit.). Based on this relationship the following formula for back-calculating lengths, at the time of formation of different annuli, was used.

$$\log l_n = \log L_t + b\ (\log r_n - \log R_t).$$

Where ln=length at age n ; Lt=length at the time of capture ; r_n=radius of the vertebra at age n ; R_t=the total radius of the vertebra at the time of capture ; and b=slope of the regression line. The advantage in using this formula is that the estimates are based on a calculated slope which eliminates any errors arising when a direct relationship is assumed. The mean values of the back-calculated lengths are presented in Table 1.

TABLE 1

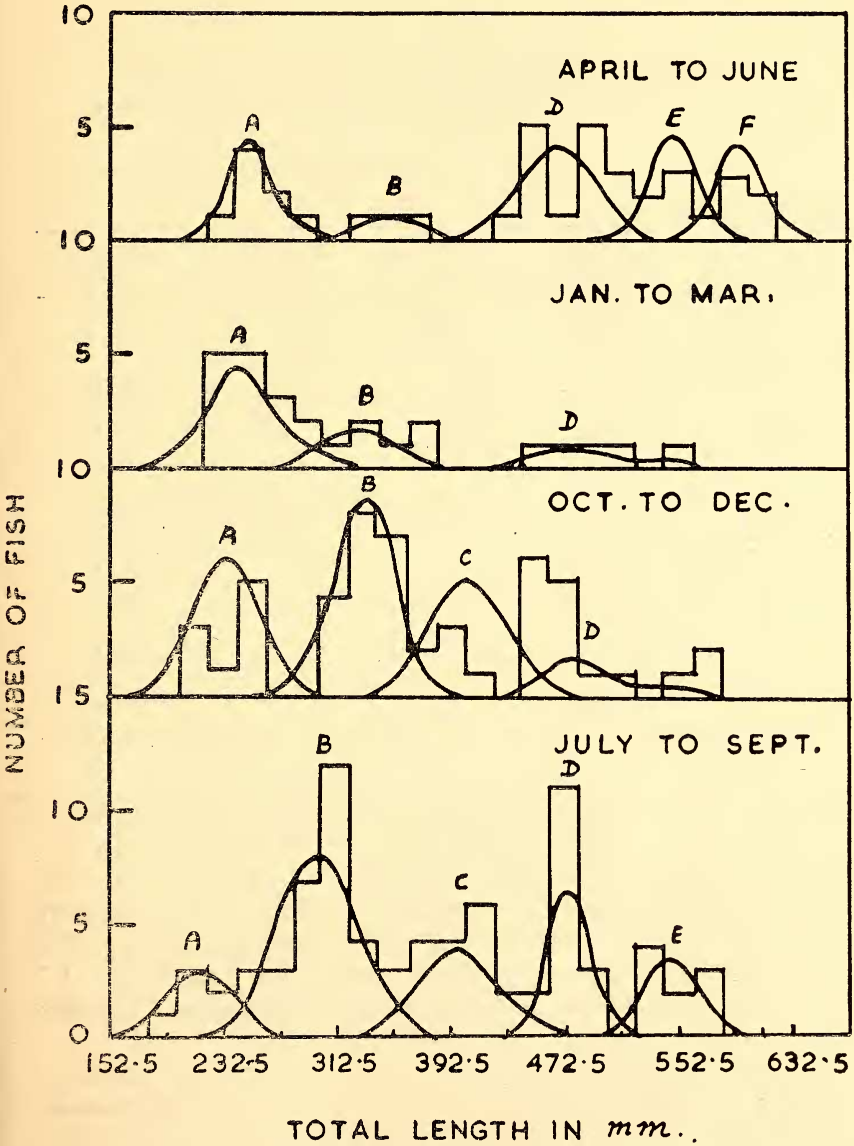
MEAN BACK CALCULATED LENGTHS (MM.) AT THE END OF EACH YEAR OF LIFE OF ALL AGE GROUPS OF *T. sona*

Length at capture	Number of Specimens	Age in years				
		1	2	3	4	5
205	2	183·2	—	—	—	—
265	3	192·9	298·3	369·2	—	—
325	4	228·9	292·7	398·7	—	—
345	4	229·6	284·4	299·7	323·2	—
352	6	212·9	287·1	307·0	390·9	—
393	4	270·9	306·8	356·0	393·2	—
405	2	261·0	310·7	373·5	395·6	400·7
413	1	265·5	326·6	372·2	395·0	—
435	3	271·9	337·0	386·3	408·6	428·0
445	3	—	345·7	380·2	410·4	431·4
450	2	284·4	351·4	393·4	422·6	437·5
460	4	223·6	339·5	395·5	416·2	434·9
465	1	202·1	354·8	400·7	429·0	454·0
470	2	212·7	342·9	407·4	431·3	465·1
500	4	205·6	—	398·9	433·2	—
510	1	—	361·3	415·9	450·4	475·8
550	3	242·5	379·5	405·0	466·5	505·4
570	2	—	318·4	403·9	472·0	534·4
Total	51					
	Mean	229·9	315·6	384·4	417·0	454·0

The length frequency polygons as have been used by many workers for determining the age of fishes was found to be very useful in the case of *T. sona* which has a restricted spawning season (Singh 1965).

Cassie (1954) made use of the arithmetic probability paper to dissect out different length groups and determine graphically the mean and the standard deviation of each group. The method suggested by Cassie (op. cit.) has been followed in the present study. After estimating the mean and the standard deviation, the frequency distribution was calculated by using the value of $\frac{x-\bar{x}}{\delta}$ as argument to enter the probability table where $(x-\bar{x})$ is the difference between the mean length and a given value.

The modal values of the length frequency distribution in the first quarter given in Table 2 and plotted in figure 2, were 212·5, 296·5,



Text-Fig. 2. Size frequency distribution of *T. sona* for the year 1963-64 represented quarterly. The year classes have been separated by probability plot.

396·5, 472·5, and 544·5 which were designated as 'A', 'B', 'C', 'D', and 'E' respectively for convenience of following their subsequent progression. The mode 'A' showed a progression of 20 mm. by the time it reached the second quarter that is from October to December, in the third and fourth quarters that is from January to March and from April to June an increase of 12 mm. and 8 mm. respectively was observed.

TABLE 2

MEAN VALUES OF LENGTH OF DIFFERENT SIZE GROUPS SEPARATED BY PROBABILITY PLOT AND MODES CORRESPONDING TO VARIOUS CLASSES GROUP ASSIGNED

Expected age group	Year 1963-64			
	July to September	October to December	January to March	April to June
1 (A)	212·5 (24·0)	232·5 (20·0)	244·5	252·5 (15·0)
2 (B)	296·5 (26·0)	327·5 (19·0)	330·5 (29·0)	344·5 (26·0)
3 (C)	396·5 (36·0)	404·5 (12·0)	—	—
4 (D)	472·5 (15·0)	482·5 (40·0)	492·5 (36·0)	500·5 (30·0)
5 (E)	544·5 (29·0)	—	—	552·5 (5·0)
6 (F)	—	—	—	587·5 (15·0)

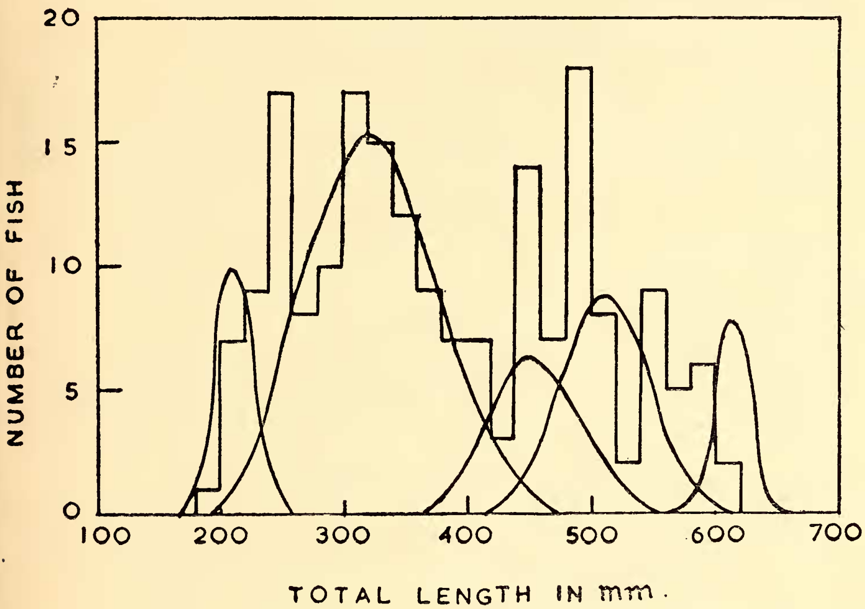
Note: The standard deviation is given in parentheses, A. B. C. D. E. F, indicate modes in Fig. 2.

The progression of the mode marked as 'B' from the first quarter to the second quarter was found to be 35 mm. showing no substantial progression in subsequent quarters. The mode 'C' showed a moderate increase from the first quarter to the second quarter, being completely absent in the samples examined during the remaining period. The mode 'D' remained at the same value throughout the year whereas 'E' appeared in the first quarter and again in the last quarter and 'F' only in the last quarter.

The above account does not give any reliable index of the increase in length from one quarter to the next of each year class probably because the samples were not large enough to account for shifting of the modes from one year class to the next. However, it did give a rough estimate of different year classes in different quarters of the year.

It may be seen that the younger age-groups below five years were present only in the samples obtained during October-March, while in the next half year (April-September) the samples were fairly well represented by older fish.

When the length frequency distribution of all the samples, obtained during the period June 1963 to June 1964, were plotted as histograms (Fig. 3) and the normal curves were fitted to the data, by following the



Text-Fig. 3. Size frequency distribution of *T. sona* for 1963-64, showing the various year classes separated by the probability method.

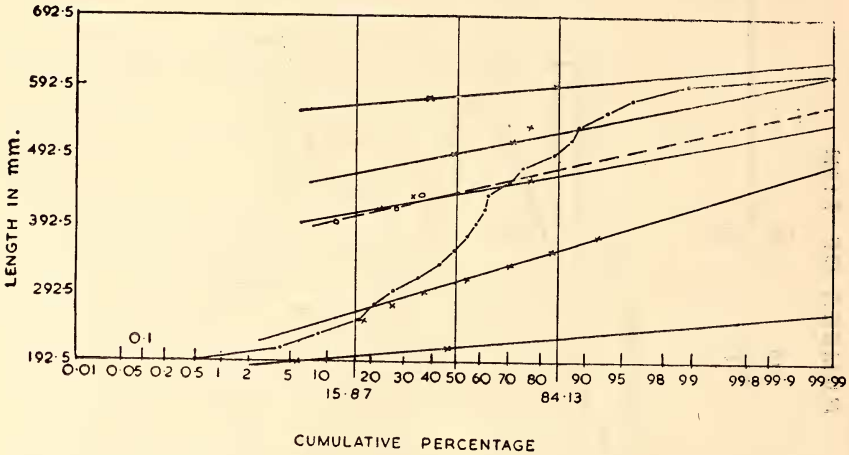
TABLE 3

MEAN VALUES AND STANDARD DEVIATIONS OF DIFFERENT SIZE GROUPS IN THE POOLED SIZE FREQUENCY DISTRIBUTION

Year Class	m	s	Percentage of total	n
1	212·5	12	8·8	17
2	307·5	49	49·3	95
3	—	—	—	—
4	432·5	40	16·1	31
5	492·5	33	19·1	37
6	572·5	17	6·7	13
			100·0	193

m = mean.
s = standard deviation.
n = number.

method described above, the mean values obtained by the probability plot were 210, 325, 450, 510 and 610 (Fig. 4). These are given in Table 3 along with their standard deviations. The modal values thus obtained agreed very closely with the back calculated lengths of different year-classes (Table 4), determined from the zones on the vertebrae. However, in the third year the modal length 384·4 mm. did not agree well. This may be probably due to the absence of this year-class in the length frequency histograms.



Text-Fig. 4. Probability plot of the length frequency distribution of *T. sona* showing the method of separating the theoretical curve components.

TABLE 4

COMPARISON OF MEAN LENGTH CALCULATED BY BACK CALCULATION AND LENGTH FREQUENCY DISTRIBUTION

Age in years	Vertebral studies	Modes of length frequency
1	229·9	210
2	315·6	325
3	384·4	—
4	417·0	450
5	454·0	510
6	—	610

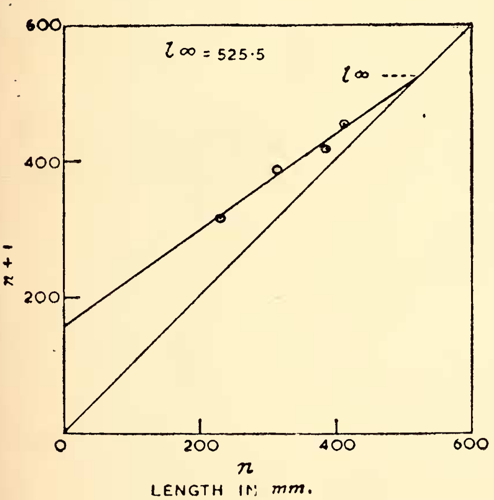
The close correspondence between the back calculated average lengths and the observed modal lengths substantiates the validity of growth checks on the vertebrae as annular and justifies their use for age determination. In the case of *T. sona*, the formation of the clear cut growth rings on the vertebrae may probably be attributed to the stress of spawning, which is annual and restricted to a short period. In addition to that, the habit of buccal incubation of eggs in this fish, leads to a suspension of feeding which probably acts as a growth retarding factor (Singh op. cit.).

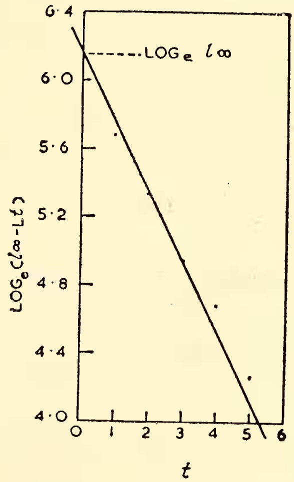
Empirical Growth

The von Bertalanffy (1938, 1957) growth equation,

$$l_t = l\infty\,(1 - e^{-k(t - t_0)})$$

where l_t=length at age t ; $l\infty$=maximum length to which the fish can grow ; K=catabolic coefficient ; t=age of fish ; t_o=theoretical value of age when length is zero, is used for fitting the growth curve of *T. sona* ; the value of $l\infty$ was determined by using the graphical method of Walford (1946), (Fig. 5). The value of t_o is calculated graphically according to the method given by Ricker (1958) and is shown in Fig. 6.





Text-Fig. 5. The length and age data plotted at age t against length at age t+1. The intersection of the bisector gives an estimate of L∞

Text-Fig. 6. Log (L∞ − lt) plotted against age ' t ' for estimating t_o.

The estimated values of $l\infty$; k and t_0 describing the growth of *T. sona* are as follows :

$$l\infty = 525{\cdot}5,\ k = 0{\cdot}3507,\ t_0 = -0{\cdot}69.$$

The von Bertalanffy growth equation of *T. sona* may be written as,

$$l_t = 525.5\ (1 - e^{-0.3507\ (t-(-0.69)}\ )$$

From the above growth equation the length of a fish at various year-classes can be calculated. The calculated values of lengths at different ages are given in Table 5. These were found to agree closely with the observed lengths at different ages.

Length-weigth Relationship.

The weight of the ungutted fish was taken to the nearest gramme and the average weight when plotted against 10 mm. size interval

TABLE 5

AVERAGE LENGTHS OF *T. sona* ESTIMATED BY VARIOUS METHODS CORRESPONDING TO YEAR-CLASSES

Age in years	Vertebra studies	Theoretical growth equation	Modes of length frequency distribution
1	229	234	210
2	315	320	325
3	384	380	—
4	417	423	—
5	454	453	450
6		474	—
7		489	—
8		499	—
9		506	—
10		512	510

(Fig. 7), gave the relationship of the curvilinear type. This can be described by the equation :

$$W=aL^{b}$$

The equation can also be written as,

$$\log W=\log. a+b \log L.$$

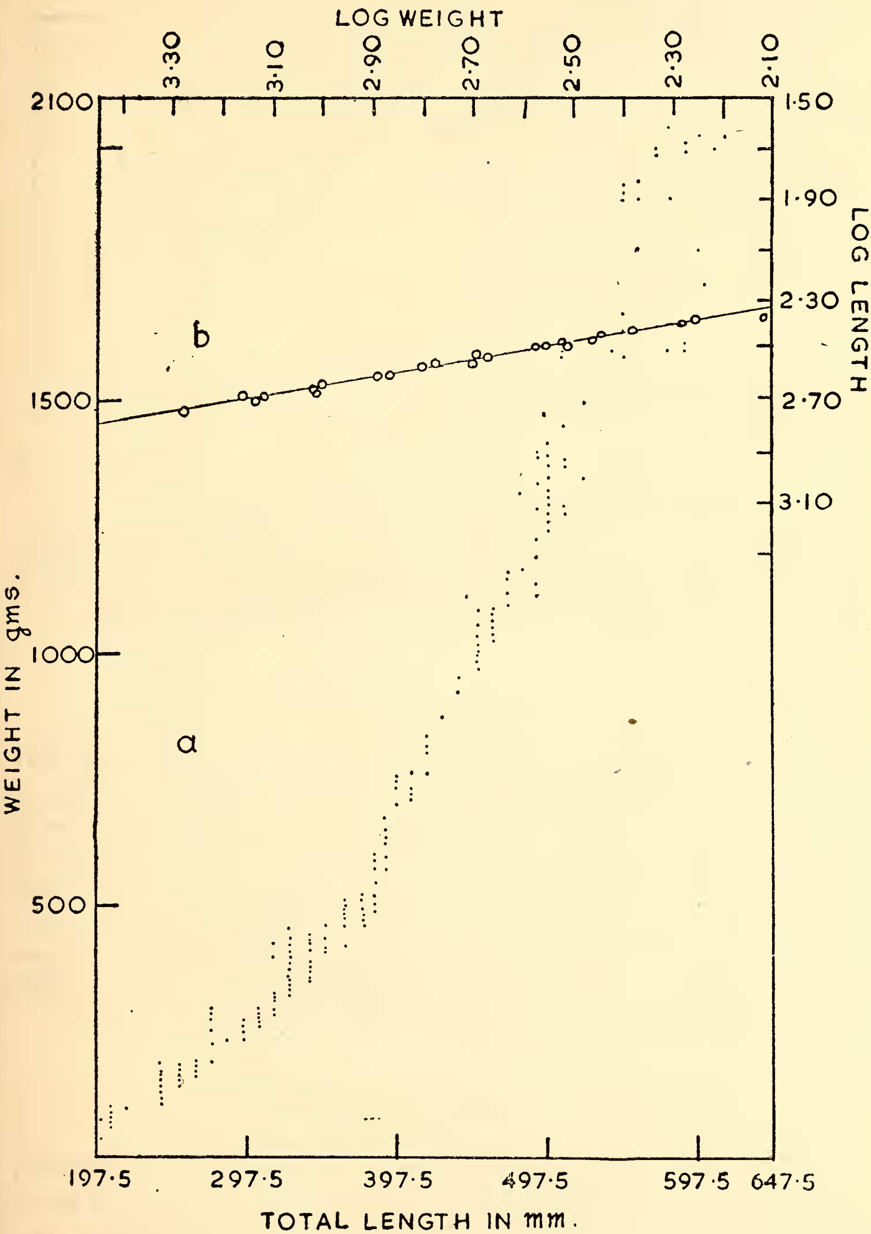
Accordingly, the length-weight relationship of *T. sona* was found to be as

$$\log W=-4{\cdot}794868+2{\cdot}932107 \log L.$$

The coefficient of correlation 'r' =0·9848 is highly significant and shows that the relationship follows strictly the cube law, which is not always true in catfishes. Appleget & Smith (1951) gave the value of 'b' as 3·66, in channel catfish which shows that weight increases at a power much greater than the cube of the length, indicating that the relationship between length and weight deviates from the cube law.

Relative condition

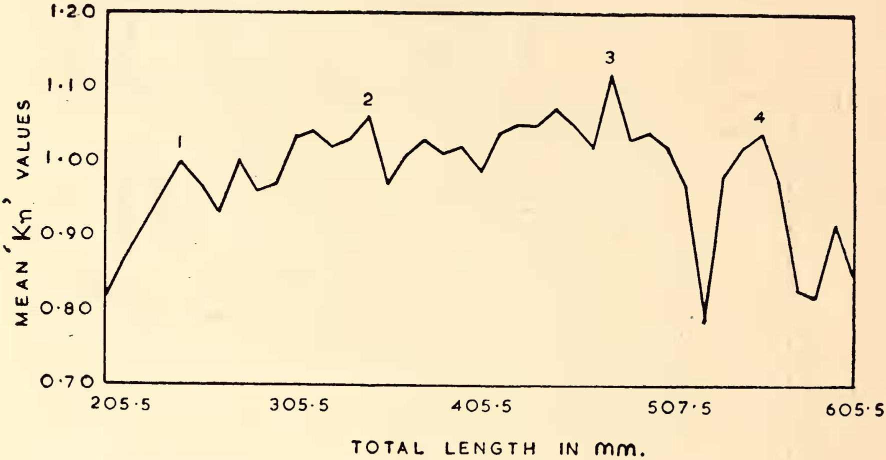
The changes in the condition of the fish or the 'k' value largely depend on the state of the fish and therefore it gives a good indication of the spawning period. Le Cren (1951), reviewed the limitations of using the formula $K=\frac{W}{l_3}\times 100$ in the case of those fish which do not obey the cube law and suggested a modification to account for the deviation in the length-weight relationship. The modified formula is $K_n=\frac{W}{\hat{W}}$ where 'W' is the observed weight and $\hat{W}$ is the calculated weight according to the length-weight relationship. In the present study the 'K_n' values were calculated using this modified formula.



Text-Fig. 7. Length-weight relationship of *T. sona*

(*a*) Scatter diagram of absolute values.
(*b*) Log-log—transformation.

From the variations in the ' K_n ' values at different lengths as shown in Figure 8, it appears that the fish spawns for the first time when it is



Text-Fig. 8. Mean ' Kn ' values at different lengths of *T. sona*.

about 240 mm. in length that is in the second year of its life. Subsequent spawnings take place when the fish attains the lengths of about 345, 475, and 525 mm. i.e. in the 3rd, 4th, and 5th year of its life.

Summary

Age determination of *T. sona* was made from the zones on the vertebrae. The back-calculated lengths of each year class were used to study the growth of fish and to show the accuracy of back calculations. The results were compared with the length frequency histograms. A close agreement was obtained between observed and back calculated lengths. The age-length data were used to estimate the growth parameters of the von Bertalanffy growth equation. Length-weight relationship of the fish was determined and the fluctuations in the condition factor (k) which probably correspond to the spawning were noticed.

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